Clouds and the Earth's Radiant Energy System (CERES)

Validation Plan

ERBE-Like Inversion to Instantaneous TOA Flux

(Subsystem 2.0)

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ERBE-LIKE INVERSION TO INSTANTANEOUS TOA FLUXES

2.1 INTRODUCTION

The ERBE-like Inversion Subsystem consists of a number of algorithms necessary to the determination of the instantaneous flux at the top-of-the-atmosphere (TOA). These algorithms are described in the ATBD. The “Spectral Correction Algorithm” (ATBD 2.2.1) corrects the filtered radiances to unfiltered radiances and is a function of scene type and viewing geometry. The observed scene type is identified with the “Maximum Likelihood Estimation” (MLE) technique (ATBD 2.2.2). Once the scene type is known, the “Radiance-to-Flux Conversion” (ATBD 2.2.3) is accomplished with “Angular Distribution Models” (ADM). The main objective of this section is to validate the algorithms used to determine the TOA flux.

2.1.1 Measurement and science objectives

The CERES scanning radiometers measure the earth radiance in three spectral bands and are discussed in Section 1.1.1. We will refer to these measurements as the shortwave (SW), total (TOT), and window (WN) measurements.

2.1.2 Missions

The CERES scanners will be launched aboard the TRMM spacecraft and the EOS AM and PM platforms (see Section 1.1.2)

2.1.3 Science data products

The science data product is the ES-8 (ATBD Section 2.0 App. B-5) which contains measurement time, location, radiances, scene types, and TOA fluxes. The validation plan for the time, location, and radiances are in Section 1.0. The validation of the scene types and TOA fluxes are discussed in this section.

2.2 VALIDATION CRITERION

2.2.1 Overall approach

The Spectral Correction Coefficients (SCC) that convert the SW and TOT filtered measurements to SW and longwave (LW) unfiltered measurements are validated by a three channel intercomparison (Section 1.3.3.3, Green and Avis 1996). For ERBE with its longwave channel this redundancy check was straightforward. For CERES we will need to transform the narrowband window measurement to an estimate of a broadband longwave measurement. This will add uncertainty to the comparison, but not eliminate the usefulness of the test. Since a calibration change and a SCC change affect a measurement in a similar manner, it will be difficult, if not impossible, to distinguish between the two in some cases.

The scene identification algorithm has been well studied and documented (Wielicki and Green 1989, Diekmann and Smith 1989, Smith and Manalo-Smith 1995). Using CERES scene results, we will determine the frequency of clear, partly cloudy, mostly cloudy, and overcasts and compare them against the historical ERBS results.

The angular distribution models for the CERES ERBE-like product will be the same as used for ERBE (Suttles et al. 1988, 1989). Validation studies have shown an erroneous growth of albedo from nadir views to limb views (Green et al. 1990, Suttles, et al. 1992). In addition there are latitudinal effects of unknown origin. If a better set of ERBE-like ADMs becomes available, then they will be used to process ERBE-like fluxes and the various ADM validation studies redone. A new set of ERBE-like ADMs would also require reprocessing the ERBE data to maintain the long-term consistency between ERBE and ERBE-like results.

2.2.2 Sampling requirements and trade-offs

If the best available ERBE-like ADMs are declared invalid by the CERES Science Team, then new replacement ADMs could be constructed with a minimum of 4 months of TRMM RAP (rotating azimuth plane) data.

2.2.3 Measures of success

The measure of success for the spectral correction coefficients is tied to successful radiances (Section 1.0). In addition, the three channel intercomparison can detect inconsistencies with scene type. To be valid, the SCC should have uniform biases for all 12 scene types consistent with ERBS results (Green and Avis 1996).

The ERBE MLE scene identification algorithm is part of the ERBE heritage and is valid by the definition of ERBE-like. The purpose of the ERBE-like products is to continue this heritage and produce a long-term radiation product. Thus, the frequency of scene types will be monitored for quality control. If erroneous cloud amounts occur relative to ERBS, they will most likely result from measurement or sampling problems and not a problem with the scene identification algorithm.

Angular distributional models are difficult to validate and there is no known way to insure success. At best we can define characteristics they should posses such as removing the effect of viewing geometry on the resulting flux estimates. The characteristic of viewing zenith and solar zenith reciprocity is not widely accepted for all scene types. For those scene types for which there is some agreement (such as clear ocean, snow, and desert) there is no unique way to force reciprocity on the model (Green et al. 1990). In general more data will improve a model. This is not the case for ADMs. The albedo growth in the ERBE production ADMs constructed with Nimbus-7 data would probably not have been corrected with twice the amount of data. There are two available methods to construct ADMs from data and neither has shown that increased data reduces the model biases. A desirable characteristic of any set of ADMs, however, is that the construction process has converged. Thus, success in modelling the anisotropy reduces to choosing from the available sets of ADMs that have the “best” characteristics.

2.3 PRE-LAUNCH ALGORITHM TEST/DEVELOPMENT ACTIVITIES

2.3.1 Field experiments and studies

2.3.2 Operational surface networks

2.3.3 Existing satellite data

Since the ERBE-like ADMs used for ERBE (Suttles et al. 1988, 1989) have produced flux biases (Suttles et al. 1992), a new set of ERBE12 ADMs will be constructed with the RPM Method (Green and Hinton 1996) from Nimbus-7 data. These new ADMs will be validated with the SAB Method (Section 4.5.2.1.1) and the Along-track Test (Section 4.5.2.1.2). If the new ADMs are found to be significantly better than the ERBE production ADMs, then the ERBE data could be reprocessed and the new ADMs used for the CERES ERBE-like products.

2.4 POST-LAUNCH ACTIVITIES

The production ERBE-like ADMs will have been constructed most likely from Nimbus-7 ERB scanner data which has a characteristic general limb-darkening curve over tropical ocean. If the final, validated CERES radiances have a general limb-darkening curve over tropical ocean that is different, then the production ADMs and the CERES data will be incompatible and will increase the flux error estimates.

A new set of ERBE-like ADMs will be constructed with the RPM method (Green and Hinton 1996) with the first 6 months of TRMM CERES data. These new ADMs will be validated with the SAB Method and the Along-track Test. For one of those months the ERBE-like fluxes will be determined with both the production ADMs and the new ADMs. The differences in fluxes will establish a minimum uncertainty in instantaneous flux, regional flux, and global flux due to ADM uncertainty.

2.4.1 Planned field activities and studies

2.4.2 New EOS-targeted coordinated field campaigns

2.4.3 Needs for other satellite data

2.4.4 Measurement needs at calibration/validation sites

2.4.5 Needs for instrument development

2.4.6 Geometric registration site

2.4.7 Intercomparisons

2.5 IMPLEMENTATION OF VALIDATION RESULTS IN DATA PRODUCTION

2.5.1 Approach

2.5.2 Role of EOSDIS

The operational EOSDIS ES-8 product will be the data source for the validation studies. All of the validation tests including the construction of new ERBE-like ADMs will be done off-line.

2.5.3 Plans for archival of validation data

There are no plans to archive validation data except as is appropriate in formal validation articles and reports.

2.6 SUMMARY

The algorithms to convert from measured radiances to ERBE-like flux at the TOA are well established having been used in the production of the ERBE products. The major uncertainty is the ADMs that will be used to convert CERES radiances to ERBE-like fluxes. There will be three possible sets of ADMs. The ERBE production ADMs are the current choice. However, there are known biases in this set. A new set of ADMs is being constructed, prelaunch of TRMM, from the same Nimbus-7 data that was used to construct the ERBE production ADMs. A third set of ERBE-like ADMs will be constructed, postlaunch of TRMM, from the first months of TRMM data. If a set of ADMs other than the original production set is chosen, then all of the ERBE data should be reprocessed to maintain the long-term consistency between ERBE and ERBE-like results.

2.7 REFERENCES

Diekmann, F. J., and G. L. Smith, 1989: Investigation of scene identification algorithms for radiation budget measurements.*J. Geophys. Res.*, **94**, 3395-3412.

Green, R. N. and L. M. Avis, 1996: Validation of ERBS Scanner Radiances, *J. Atmos. Ocean Technol.*, **13**, 851-862.

Green, R. N. and P. O'R. Hinton, 1996: Estimation of angular distribution models from radiance pairs, *J. Geophys. Res.*, **101**, 16 951-16 959.

Green, R. N., J. T. Suttles, and B. A. Wielicki, 1990: Angular dependence models for radiance to flux conversion, *Proc. of SPIE*, **1299**, 102-111.

Smith, G. L., and N. Manalo-Smith, 1995: Scene identification error probabilities for evaluating Earth radiation measurements, J. *Geophys. Res.*, **100**, 16377-16385.

Suttles, J. T., R. N. Green, P. Minnis, G. L. Smith, W. F. Staylor, B. A. Wielicki, I. J. Walker, D. F. Young, V. R. Taylor, and L. L. Stowe, 1988: Angular radiation models for Earth-atmosphere system. Part I: Shortwave radiation, NASA Reference Publication 1184, Vol. I.

Suttles, J. T., R. N. Green, G. L. Smith, B. A. Wielicki, I. J. Walker, V. R. Taylor, and L. L. Stowe, 1989: Angular radiation models for the Earth-atmosphere system. Part II: Longwave radiation, NASA Reference Publication 1184, Vol. II.

Suttles, J. T., B. A. Wielicki, and S. Vemury, 1992: Top-of-atmosphere radiative fluxes: Validation of ERBE scanner inversion algorithm using *Nimbus-7* ERB data, *J. Appl. Meteor.*, **31**, 784-796.

Wielicki, B. A., and R. N. Green, 1989: Cloud identification for ERBE radiation flux retrieval, *J. Appl. Meteor.*, **28**, 1133-1146.

CERES VALIDATION SUMMARY

Subsystem 2.0 - ERBE-like Inversion to Instantaneous TOA Fluxes

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Data Products and Parameters

- Parameters: ERBE-like ADMs, ERBE-like TOA flux
- Product: CERES ES-8

Approach

- Test ADMs with SAB Method (SAB monthly means independent of ADMs)
- Build new ADMs from CERES data
- Constant Flux Test (flux consistency with viewing zenith)
- Compare ERBE-like flux with CERES flux (same data, different scene ID and ADMs)
- Intercompare ERBE-like flux from TRMM and EOS AM-1.

Validation Activities

- Prelaunch
    1) Test ADMs with SAB Method using Nimbus-7 data
    2) Apply Constant Flux Test to ERBE along-track data
    3) Validate data processing system using CERES simulation
    4) Establish mean and variance of difference between ERBE-like flux and CERES flux from CERES simulation
- Postlaunch
    1) Test ADMs with SAB Method using CERES RAP data
    2) Build new ERBE-like ADMs from CERES data and compare with current ADMs.
    3) Apply Constant Flux Test with CERES data
    4) Determine flux difference between ERBE-like flux and CERES flux and test against prelaunch statistics

Archive

- All validation tests are off-line.